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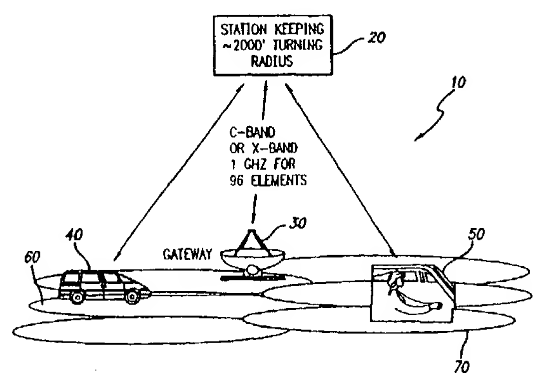
(54) Title: MICRO CELL ARCHITECTURE FOR MOBILE USER TRACKING COMMUNICATION SYSTEM




(57) Abstract: A system and method for tracking a user. The system is adapted for use in a wireless communication system and creates a plurality of beams within a coverage area. A first beam is directed at a user in a first microcell and a number of additional beams illuminate microcells immediately adjacent the first microcell. The system is equipped with a mechanism for detecting movement of the user from the first microcell to one of the immediately adjacent microcells. On the detection of movement of the user, the system redirects the first beam from the first microcell to a second microcell, the second microcell being one of the adjacent microcells. In the illustrative embodiment. The system is implemented in a stratospheric platform based communication system including a hub adapted to communicate with a stratospheric platform. A transceiver and a phased array antenna are disposed on the platform to communicate with the hub and with the user. A second antenna is provided on the platform to communicate with the hub. Beamforming and direction are implemented on the hub and communicated to the platform. The user's position is detected with a global positioning system receiver, by measuring the strength of a signal received from the user, or by other suitable means. On detection of user movement from the first microcell, the beamforming system redirects the beam to follow the user into a second microcell. Additional beams around the user's microcell are illuminated to facilitate detection of the users movement.

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# MICRO CELL ARCHITECTURE FOR MOBILE USER TRACKING COMMUNICATION SYSTEM

## BACKGROUND OF THE INVENTION

### Field of the Invention:

The present invention relates to communications systems. More specifically, the present invention relates to architectures for data/voice services to mobile users using stratospheric platforms.

### Description of the Related Art:

Stratospheric platforms are being considered for data/voice communication applications. Current proposals envision a mounting of transceivers and antennas on aircraft flying at 20 - 30 kilometers above the earth which will project beams to cell sites located on the ground.

Copending U. S. Patent Application No. 09/588,395, filed 6 June 2000 by D. Chang *et al.*, entitled **STRATOSPHERIC PLATFORM BASED MOBILE COMMUNICATIONS ARCHITECTURE,** the teachings of which are incorporated herein by reference, addressed the need in the art for a stratospheric platform based communication system offering maximum throughput with the constraints of weight, power and spectrum. In accordance with the teaching of the referenced patent application, communication between users and external networks is facilitated through stratospheric platform and a hub located on the ground. Beamforming is performed at the hub. Signals to and from the user are communicated via directional beams through a phased array antenna on the platform under the directional control of the hub.

a user scheme, the user would not have to change his CDMA code unless he gets to close to another user who is using the same CDMA code. (A code assignment algorithm is a subject of a copending U. S. Patent Application No. ______________ entitled **A NOVEL ALGORITHM FOR CDMA CODE ASSIGNMENT BASED ON DYNAMIC CELLS**, filed ___________, by ___________, (Atty. Docket No. ________) the teachings of which are incorporated herein by reference.)

Hence, a need exists in the art for a system and method for tracking the position or location of a user in a stratospheric platform based communication system.

## SUMMARY OF THE INVENTION

The need in the art is addressed by the system and method for user tracking of the present invention. The inventive system is adapted for use in a wireless communication system and creates a plurality of beams within a coverage area. A first beam is directed at a user in a first microcell and a number of additional beams illuminate microcells immediately adjacent the first microcell. The system is equipped with a mechanism for detecting movement of the user from the first microcell to one of the immediately adjacent microcells. On the detection of movement of the user, the system redirects the first beam from the first microcell to a second microcell, the second microcell being one of the adjacent microcells.

In the illustrative embodiment, the system is implemented in a stratospheric platform based communication system including a hub adapted to communicate with a stratospheric platform. A transceiver and a phased array antenna are disposed on the platform to communicate with the hub and with the user. A second antenna is provided on the platform to communicate with the hub. Beamforming and direction are implemented on the hub and communicated to the platform. The user's position is detected with a global positioning system receiver, by measuring the strength of a signal received from the user, or by other suitable means. On detection of user movement

in Fig. 1.

Fig. 12 is a diagram that illustrates color code assignments based on the number of users in accordance with the method of the present invention.

Fig. 13 shows a color 1 code assignment (blue) in accordance with the teachings of the present invention.

Fig. 14 shows a color 2 code assignment (pink) in accordance with the teachings of the present invention.

Fig. 15 shows a color 3 code assignment (orange) in accordance with the teachings of the present invention.

Fig. 16 shows a color 4 code assignment (purple) in accordance with the teachings of the present invention.

Fig. 17 depicts an overall code assignment.

Fig. 18 is a diagram illustrating a distribution of users sharing a code division multiplexed (CDMA) code in accordance with the teachings of the present invention.

Fig. 19 is a diagram showing an illustrative microcell architecture for use in the mobile user tracking system of the present invention.

Fig. 20 is a magnified view of a portion of the diagram of Fig. 19 showing overlap between microcells in accordance with the present teachings.

## DESCRIPTION OF THE INVENTION

Illustrative embodiments and exemplary applications will now be described with reference to the accompanying drawings to disclose the advantageous teachings of the present invention.

While the present invention is described herein with reference to illustrative embodiments for particular applications, it should be understood that the invention is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, and embodiments

array antenna 29. As discussed more fully below, the antenna 29 is a single aperture antenna that transmits and receives multiple output beams. The beams are formed and steered by a beamforming network located on the surface in the hub system 30. Each beam creates a footprint on the surface that provides a cell such as the cells shown at 60 and 70 in Fig. 1.

As discussed more fully below, the present invention allows the cell size to be non-uniform. That is, at center of coverage, or nadir, the cell can be smaller. As the scan angle increases, the cell sizes increase. The invention allows for a very light weight payload design and full utilization of the resources that a light-weight payload can offer. The present invention forms beams where there are users present with beams of shapes and sizes that are not necessarily uniform. One or more wider beams are formed to provide links supporting lower data rates. These lower data rate links are used to pick up new users trying to get on the system. This allows the coverage area to be greater with limited receiving beams. In addition, by allowing the beam size to be smaller at the center of coverage (nadir of the platform), the code or frequency reuse distance can be reduced, therefore enhancing the total system capacity.

Fig. 3 is a simplified block diagram of a hub in accordance with the teachings of the present invention. The hub transceiver system 30 includes an antenna 32 adapted to communicate with the antenna 22 on the airborne platform. The antenna 32 connects to an RF subsystem 34 which provides upconversion and downconversion in a conventional manner. The subsystem 34 receives a baseband signal from a code division multiplexer/demultiplexer 36. The multiplexer 36 receives inputs from a digital beam former 38 which is fed by conventional multiplexers/demultiplexers, routers, and formatters 39. The multiplexers/demultiplexers, routers, and formatters 39 are connected to an external network such as the Internet or World Wide Web.

The systems depicted in Figs. 2 and 3 may be implemented in accordance with the teachings of U. S. Patent No. 5,903,549, issued May 11, 1999 to Von Der Embse and entitled Ground Based Beam Forming Utilizing Synchronized CDMA, the teachings of which are hereby incorporated by reference herein. The number of beams (or simultaneous users) 'n' is scaleable at the gateway.

is programmed to initialize new users and set up the links therefor. In addition, in accordance with the present teachings, the controller 45 is programmed to recognize conflicts and reallocate codes for certain users as necessary in the manner discussed more fully below.

A spread user signal is output by the encoder/decoder 41 to a digital beam former 38. The beam former 38 is a conventional beam forming system which provides element phasing information to direct a beam containing the spread user signal and amplitude information to shape each beam for each user. These beam formed user signals are summed by an adder 37 and input to a CDMA antenna element spreading encoder 36. In the illustrative embodiment, the element spreading encoder 36 uses orthogonal codes to spread the signal for each element in response to an element code supplied by a register or memory 35. The user signals might be on the order of 144 kilobits per second bandwidth, spread to 5 megahertz by the encoder 41, and spread further to .5 to 1 gigahertz by the element spreading encoder 36. The signals from the elements are summed by a second adder 31 and input to the radio frequency stage 34. In the illustrative embodiment, the RF stage is an RF transceiver which outputs a right-hand circular (RHC) signal in the C-band or X-band range. In practice, a second identical circuit 30' (not shown) would output a left-hand circular (LHC) signal as well. These signals are combined at the antenna 32 and uplinked to the platform 20 depicted in Fig. 1.

Fig. 5 is a functional block diagram illustrative of the forward processing of the platform in accordance with the present teachings. As shown in Fig. 5, the uplinked signal is received by a feeder antenna 22 and fed to LHC and RHC processing circuits 20 and 20' of which only the LHC circuit 20 is shown. Each processing circuit 20 includes an RF transceiver 24 which downconverts the (C-band) uplink feed of one polarization and outputs feeder signals for each antenna element. The element signals are despread by an element decoder 26 in accordance with a code stored in a memory 51 associated with each element. A signal for a given element is upconverted to S-band, in the illustrative embodiment, and combined with the corresponding signal output by the processing circuit 20' for the RHC by a summer 27 which outputs an element downlink

in accordance with the teachings of the present invention. The signal downlinked from the platform is received by the antenna 32 and separated into RHC and LHC downlink feeds. Each feed is downconverted to IF by the C-band RF transceiver 34. The downconverted signal is despread by the CDMA decoder 36. The element returns for each user are processed by the beamforming processor 38 in response to the stored phases and weights supplied by the database 47. The spread user data is then supplied to the CDMA decoder 41 which decodes the data in response to a user code supplied by the database 47. The decoder 41 outputs user data suitable for transmission over the network connected to the multiplexer 39.

In the preferred embodiment, each beam is assigned to a user or a zone. If assigned to a user, the beam is adapted to move with the user to minimize the number of code handovers and to increase antenna directivity in user links. Static beams are formed where no user tracking beams are present for new user detection.

Conventionally, the beams radiated by the antenna 29 of Fig. 2, would be constrained to provided fixed, uniform footprints or cells on the ground. If the user distribution is uniform, the equal sized cell structure is optimal. However, equal cell size comes at some cost in hardware. To avoid the need for a mechanical tracking system on the antennas, which can be costly and unreliable, the antennas are phased arrays of radiating elements and steered electronically. At a certain altitude from the ground, where a payload carrying platform locates, a same-sized ground projection cells require smaller angular beams as the scan angle increases. To form smaller beams, more antenna array elements will be needed. For a lightweight payload, the number of elements may be limited, thus forming smaller beams at the edge of the coverage may be costly.

However, in accordance with the present teachings, the beams are formed without regard to a fixed uniform pattern by the digital beam forming network 38. The system 10 is designed to cover a service area with as many users as possible. If the cell size is uniform on the ground, then the required number of elements in the phased array antenna would be so high that a light-weight payload would not be possible. On the other hand, if some elements are not being utilized to form wider beams at the

function of the distance between a user and the projected platform location on the ground (OC). The larger the OC is, the larger the spreading angles are, as shown in Fig. 10.

Fig. 10 is a set of graphs showing spreading angle as a function of distance from the projected platform location to a user of an elevated beam projection system. Note that the short-side spreading angle may be different from the long-side spreading angle.

In practice, optimal utilization of system resources calls for multiple (e.g. 200) beams to be generated. As mentioned above, in the preferred embodiment, each beam would track a user if a user were present. To maximize system capacity, the frequencies are reused by assigning codes to each beam.

In the illustrative implementation, a group of 64 codes is divided into 4 subgroups. Each subgroup of codes is referred to as one color of codes and has 16 individual codes. In the illustrative embodiment, there are four colors of codes. The assignment of one color of codes is independent of the other colors of codes. The same color of codes can be reused outside a criterion. In the illustrative embodiment, a 20 decibel (dB) sidelobe contour criterion is employed. In accordance with this criterion, a beam collision will be detected when the user moves into another cell and receives a signal therein at a level of 20 dB down from maximum or higher. The 20 dB sidelobe contours can be of different sizes and shapes throughout a coverage area.

Fig. 11 is a block diagram of an illustrative implementation of a code assignment algorithm for use in connection with the communication system depicted in Fig. 1.

Fig. 12 is a diagram that illustrates color code assignments based on the number of users in accordance with the method of the present invention. The method 100 includes the step of assigning codes with as many colors as possible (110). Next, the code colors are sorted with the number of users in descending order (step 120). Hence, as shown in Fig. 12, purple 122 might be used for 5 users, orange 124 might be used for 10 users, pink 126 might be used for 25 users and blue 128 might be used for 30 users.

Fig. 19 is a diagram showing an illustrative microcell architecture for use in the mobile user tracking system of the present invention. As shown in Fig. 19, the architecture is implemented within a cell 200 as a plurality of microcells #1 - 61 with precomputed beam weights. In the illustrative embodiment, the microcells correspond to < 1 dB antenna directivity roll-off from the peak. The present teachings are not limited to the size and shape of the microcells shown. A variety of shapes and sizes may be used to create uniform or nonuniform patterns without departing from the scope of the present teachings.

In accordance with the present teachings, for a user located at microcell #7 a finite number of beams is formed around the user (e.g. at microcells #1, 2, 6, 7, 8, 13 and 14). So long as the user remains in microcell #7, the beam direction is unchanged. However, if the user moves to microcell #8, then the signal received from microcell #8 will be greater than the signal received from microcell #7. At this point, narrow beams are shifted from microcells #1, 2, 6, 7, 8, 13 and 14 to microcells #2, 3, 7, 8, 9, 14 and 15. In short, in accordance with an illustrative embodiment of the present teachings, a narrow beam is directed to the cell at which the user is located based on strongest return signal, GPS location or other information and to an area surrounding the user defined as microcells in the preferred embodiment. The system continues to track the user as the user travels from microcell #7 to microcell #59 as depicted in Fig. 19.

For mobile users, the beam weights would have to be updated on some basis. For example, assuming a user is moving at a speed under 120 km/hr, and a beam size (with a 4-dB rolloff) of 8 km, the beam weight update rate of approximately once every minute might be adequate. As the user moves along a boundary between microcells, he may be registered with one cell, then another, then back to the original cell. This 'ping-pong' effect may be mitigated by overlapping the cells as depicted in Fig. 20.

Fig. 20 is a magnified view of a portion of the diagram of Fig. 19 showing overlap between microcells in accordance with the present teachings. With the overlap between adjacent cells, a user will not be assigned to a new microcell immediately when

## CLAIMS

1. A user tracking system for a wireless communication system comprising:

first means for creating a plurality of beams within a coverage area, a first beam being directed at a user at a first microcell and a number of additional beams illuminating microcells immediately adjacent said first microcell;

second means for detecting movement of said user from said first microcell to one of said immediately adjacent microcells; and

third means for redirecting, on the detection of said movement, said first beam from said first microcell to a second microcell, said second microcell being one of said adjacent microcells.

2. The invention of Claim 1 wherein said first means is a stratospheric platform based communication system including a hub adapted to communicate with a stratospheric platform.

3. The invention of Claim 2 further including a transceiver and a phased array antenna disposed on said platform.

4. The invention of Claim 3 further including means disposed at said hub for creating a beamforming signal for use by said phased array antenna.

5. The invention of Claim 4 wherein said second means is a global positioning system receiver.

6. The invention of Claim 4 wherein said second means includes means for measuring the strength of a signal received from said user.

7. The invention of Claim 6 wherein said hub includes said third means.

12. The invention of Claim 10 wherein said second means includes means for measuring the strength of a signal received from said user.

13. A method for tracking a user in a wireless communication system comprising the steps of:

creating a plurality of beams within a coverage area, a first beam being directed at a user at a first microcell and a number of additional beams illuminating microcells immediately adjacent said first microcell;

detecting movement of said user from said first microcell to one of said immediately adjacent microcells; and

redirecting, on the detection of said movement, said first beam from said first microcell to a second microcell, said second microcell being one of said adjacent microcells.

FIG. 1

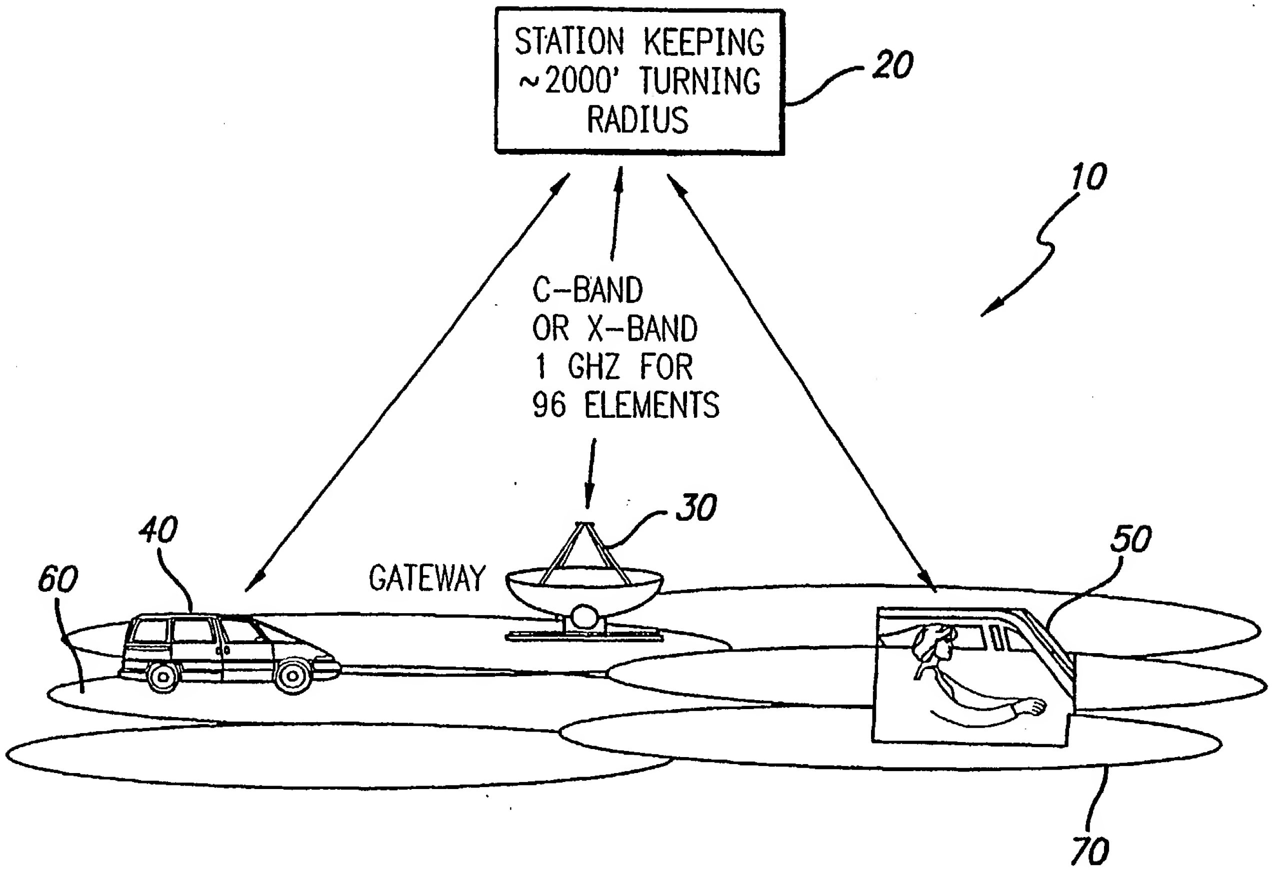
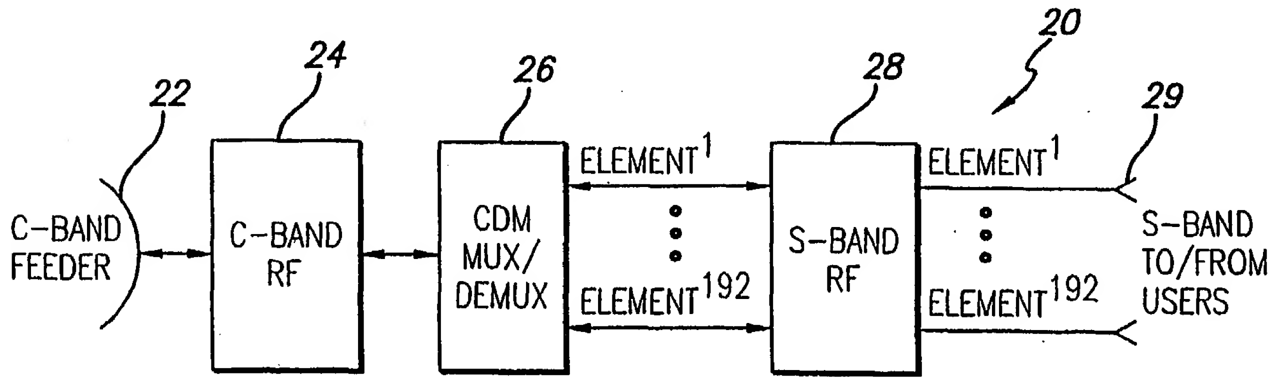

STATION KEEPING
~2000' TURNING
RADIUS
20
10
C-BAND
OR X-BAND
1 GHZ FOR
96 ELEMENTS
30
40
60
GATEWAY
50
70

FIG. 2


20
22
24
26
28
29
C-BAND
FEEDER
C-BAND
RF
CDM
MUX/
DEMUX
ELEMENT 1
ELEMENT 192
S-BAND
RF
ELEMENT 1
ELEMENT 192
S-BAND
TO/FROM
USERS

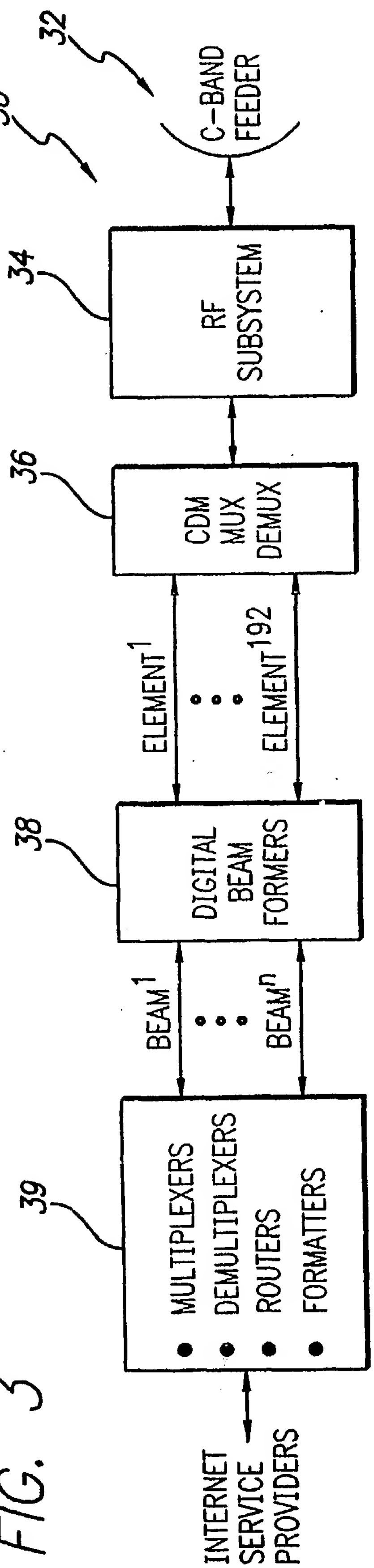

30
32
C—BAND
FEEDER
34
RF
SUBSYSTEM
36
CDM
MUX
DEMUX
ELEMENT 1
ELEMENT 192
38
DIGITAL
BEAM
FORMERS
BEAM 1
BEAM n
39
• MULTIPLEXERS
• DEMULTIPLEXERS
• ROUTERS
• FORMATTERS
INTERNET
SERVICE
PROVIDERS

FIG. 3

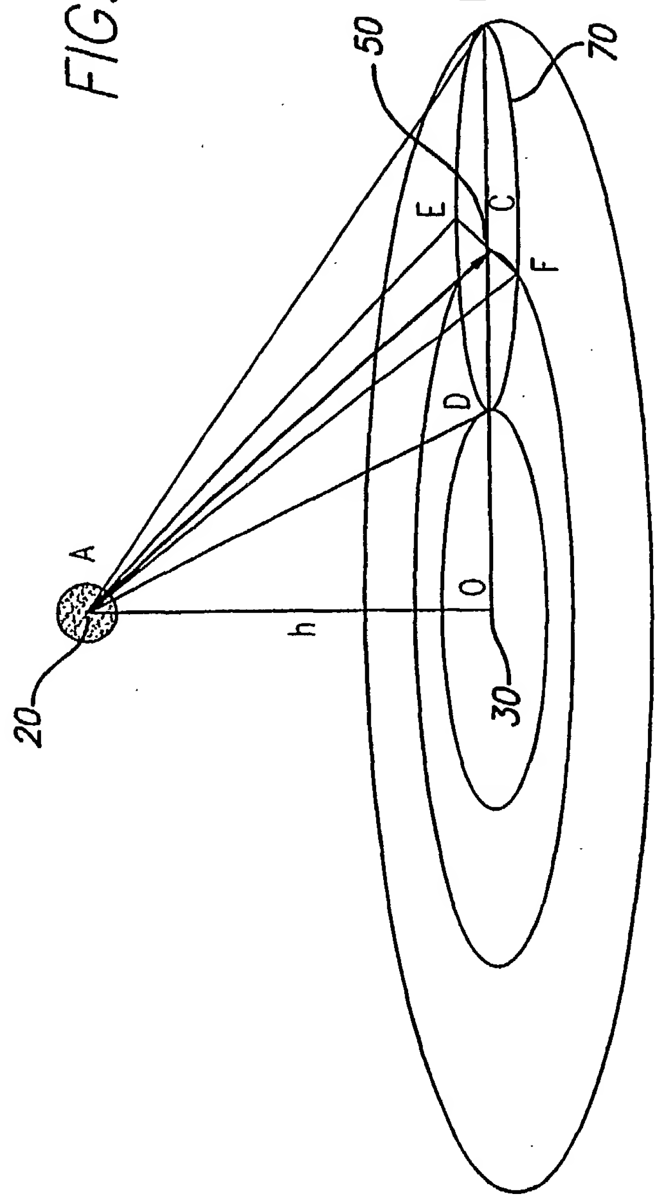

A
20
h
O
30
D
E
C
F
B
50
70

FIG. 9

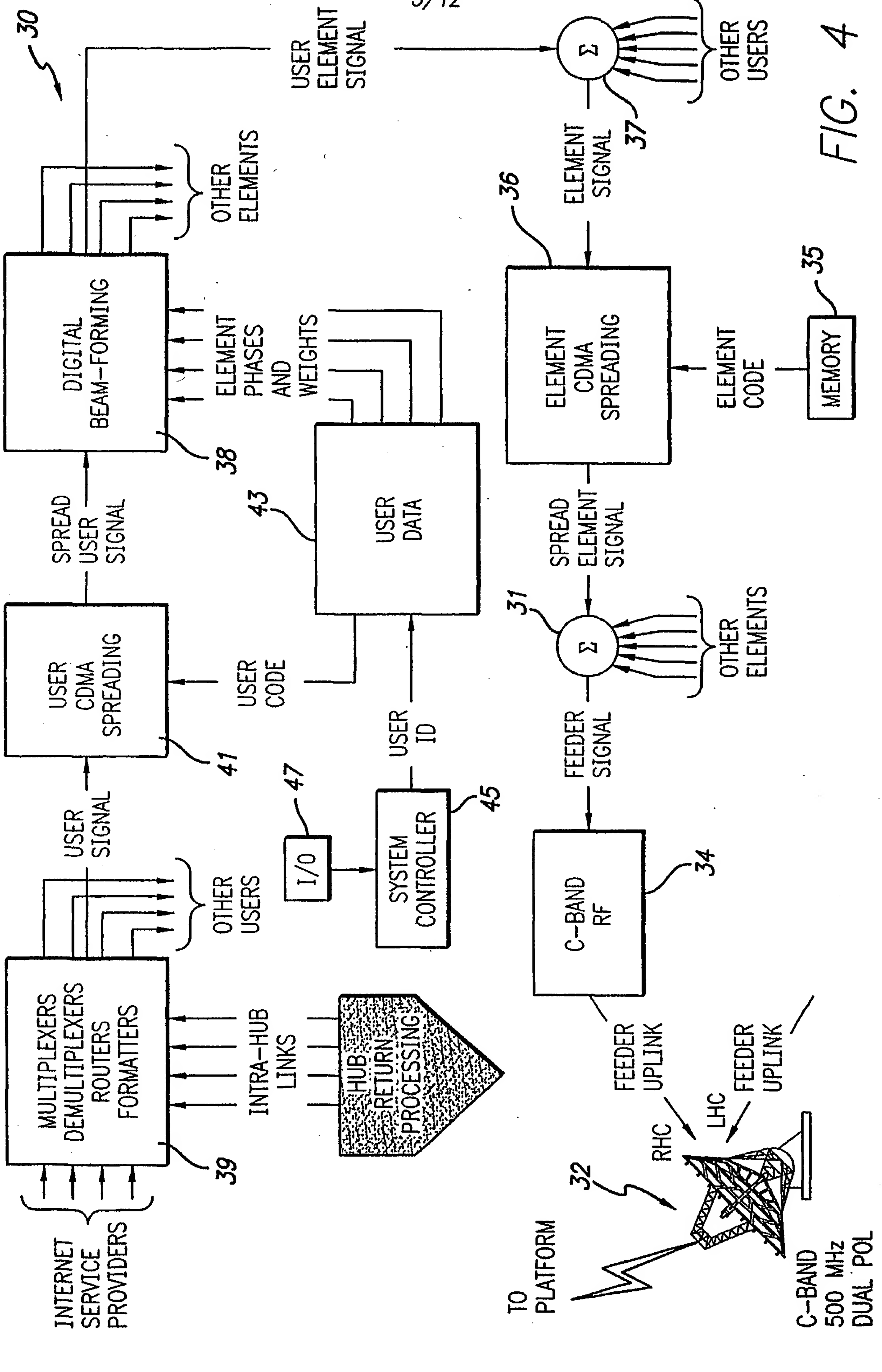

30
DIGITAL BEAM-FORMING
38
OTHER ELEMENTS
USER ELEMENT SIGNAL
Σ
37
OTHER USERS
ELEMENT PHASES AND WEIGHTS
SPREAD USER SIGNAL
USER CDMA SPREADING
41
USER CODE
USER DATA
43
USER ID
SYSTEM CONTROLLER
45
I/O
47
USER SIGNAL
MULTIPLEXERS DEMULTIPLEXERS ROUTERS FORMATTERS
39
OTHER USERS
INTRA-HUB LINKS
HUB RETURN PROCESSING
INTERNET SERVICE PROVIDERS
ELEMENT SIGNAL
36
ELEMENT CDMA SPREADING
ELEMENT CODE
MEMORY
35
SPREAD ELEMENT SIGNAL
31
OTHER ELEMENTS
FEEDER SIGNAL
C-BAND RF
34
FEEDER UPLINK
FEEDER UPLINK
RHC
LHC
32
TO PLATFORM
C-BAND 500 MHz DUAL POL

FIG. 4

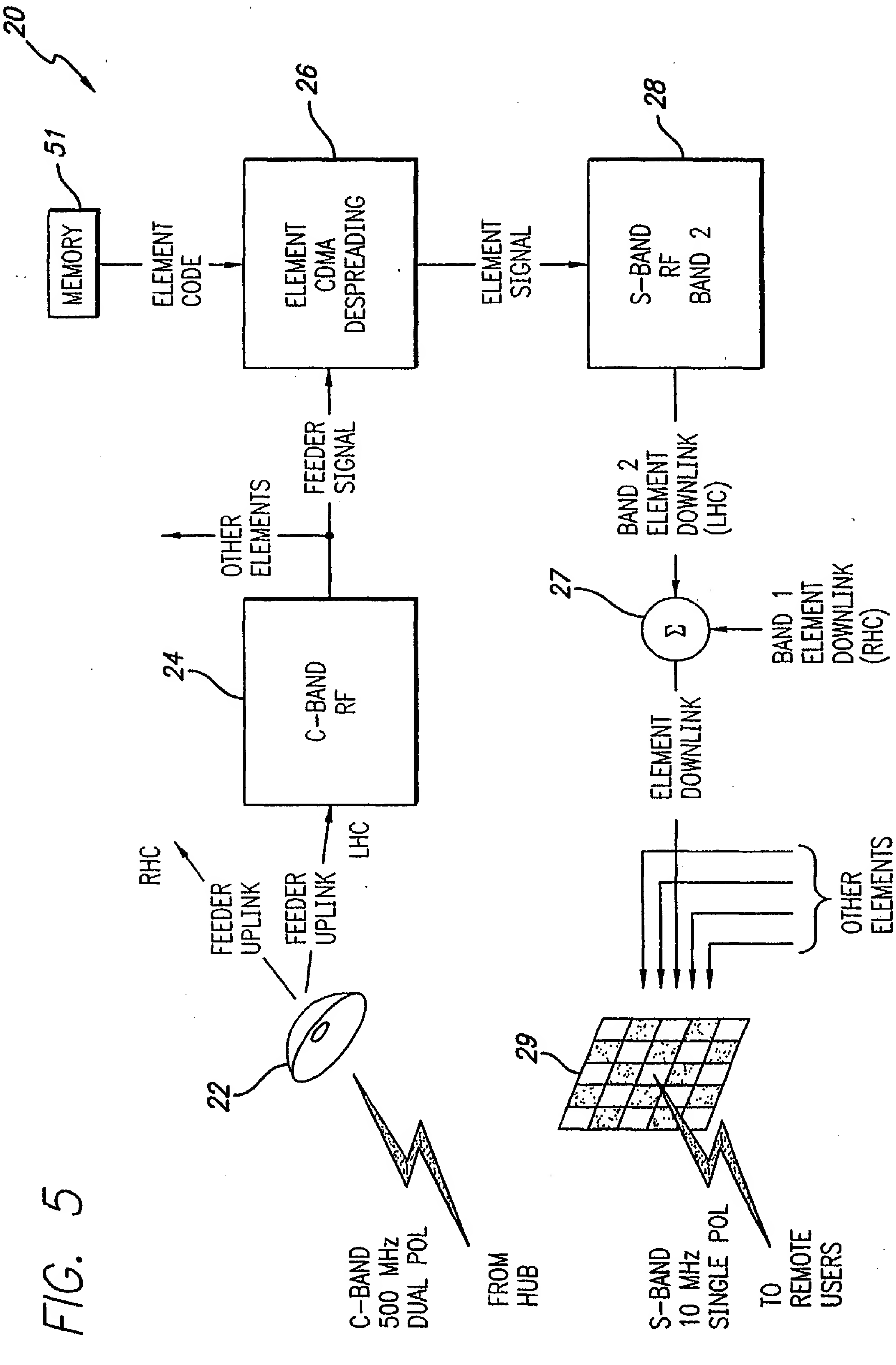

20
MEMORY
51
ELEMENT CODE
ELEMENT CDMA DESPREADING
26
ELEMENT SIGNAL
S-BAND RF BAND 2
28
FEEDER SIGNAL
OTHER ELEMENTS
C-BAND RF
24
BAND 2 ELEMENT DOWNLINK (LHC)
27
Σ
BAND 1 ELEMENT DOWNLINK (RHC)
ELEMENT DOWNLINK
RHC
FEEDER UPLINK
FEEDER UPLINK
LHC
OTHER ELEMENTS
22
29
C-BAND 500 MHz DUAL POL
FROM HUB
S-BAND 10 MHz SINGLE POL
TO REMOTE USERS

FIG. 5

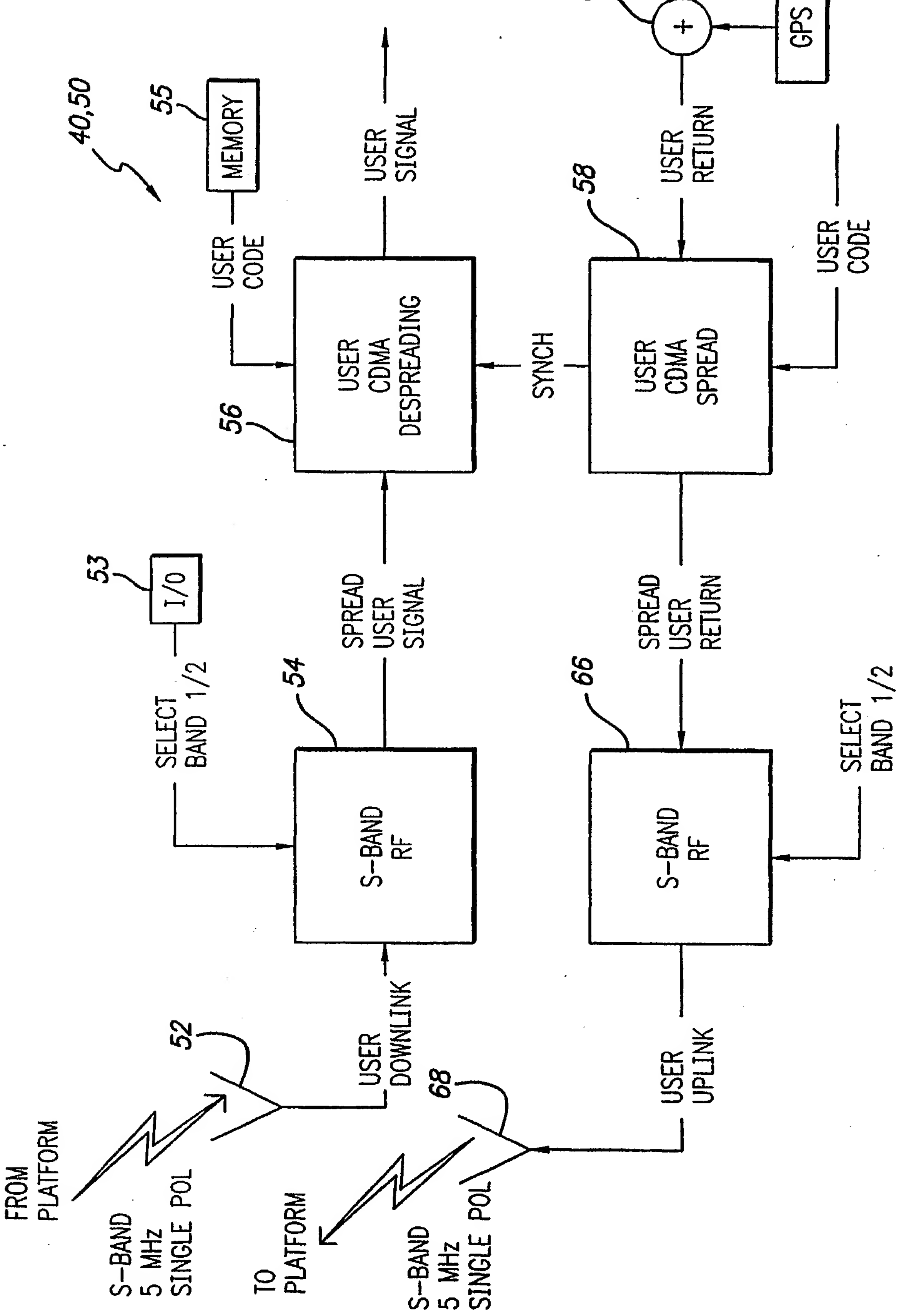

40,50
FROM PLATFORM
S-BAND 5 MHz SINGLE POL
52
USER DOWNLINK
54
S-BAND RF
SELECT BAND 1/2
53
I/O
SPREAD USER SIGNAL
56
USER CDMA DESPREADING
USER CODE
55
MEMORY
USER SIGNAL
SYNCH
TO PLATFORM
S-BAND 5 MHz SINGLE POL
68
USER UPLINK
66
S-BAND RF
SELECT BAND 1/2
SPREAD USER RETURN
58
USER CDMA SPREAD
USER CODE
USER RETURN
64
+
GPS
62
USER DATA

FIG. 6

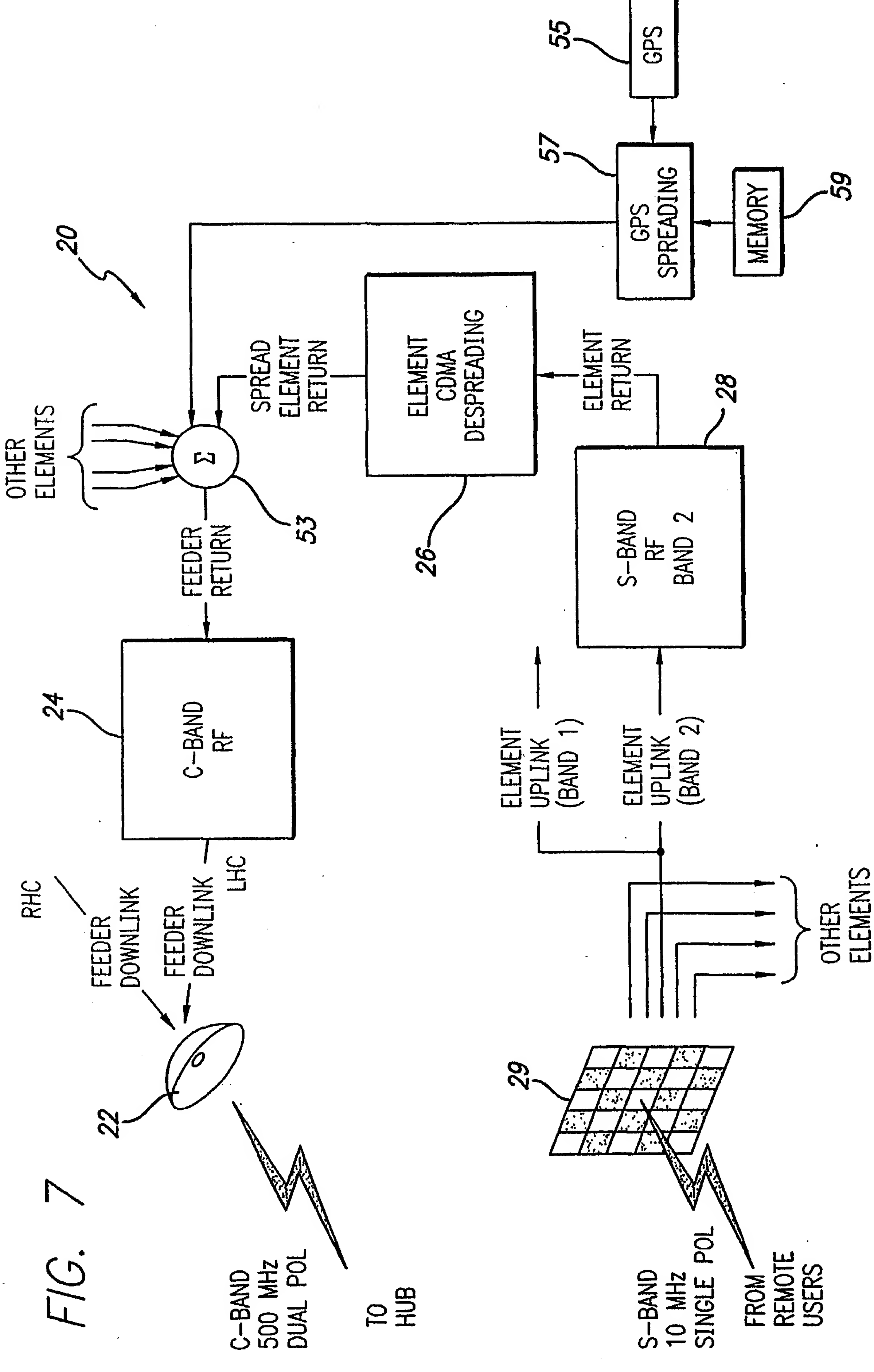

20
C-BAND 500 MHz DUAL POL
TO HUB
22
RHC
FEEDER DOWNLINK
FEEDER DOWNLINK
LHC
24
C-BAND RF
FEEDER RETURN
53
OTHER ELEMENTS
Σ
SPREAD ELEMENT RETURN
ELEMENT CDMA DESPREADING
26
ELEMENT RETURN
55
GPS
57
GPS SPREADING
MEMORY
59
S-BAND 10 MHz SINGLE POL
FROM REMOTE USERS
29
OTHER ELEMENTS
ELEMENT UPLINK (BAND 1)
ELEMENT UPLINK (BAND 2)
S-BAND RF BAND 2
28

FIG. 7

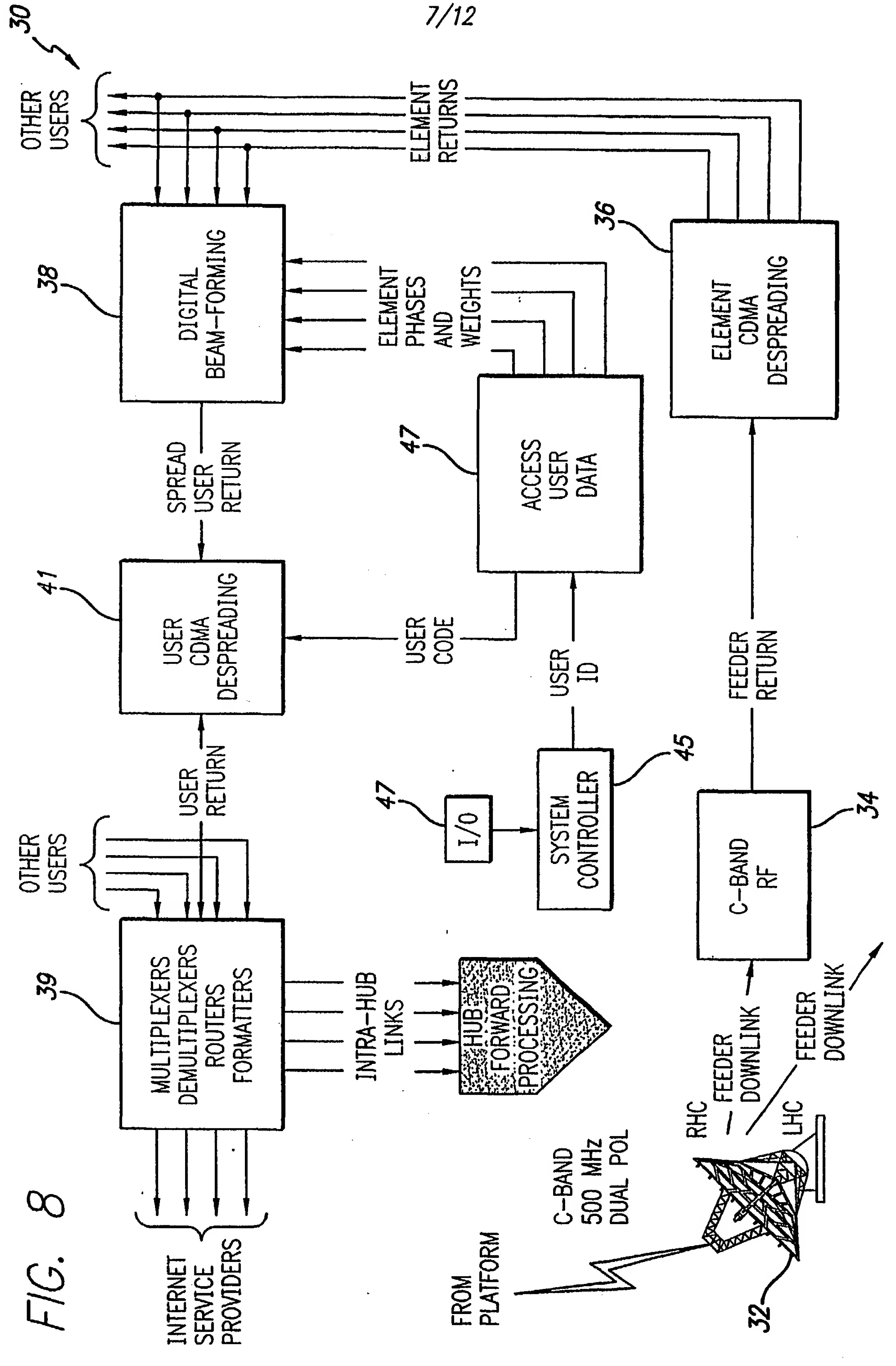

30
OTHER USERS
ELEMENT RETURNS
38
DIGITAL BEAM-FORMING
ELEMENT PHASES AND WEIGHTS
36
ELEMENT CDMA DESPREADING
SPREAD USER RETURN
47
ACCESS USER DATA
41
USER CDMA DESPREADING
USER CODE
USER ID
FEEDER RETURN
USER RETURN
45
47
I/O
SYSTEM CONTROLLER
34
C-BAND RF
OTHER USERS
39
MULTIPLEXERS DEMULTIPLEXERS ROUTERS FORMATTERS
INTRA-HUB LINKS
HUB FORWARD PROCESSING
FEEDER DOWNLINK
FEEDER DOWNLINK
RHC
LHC
C-BAND 500 MHz DUAL POL
INTERNET SERVICE PROVIDERS
FROM PLATFORM
32

FIG. 8

FIG. 10

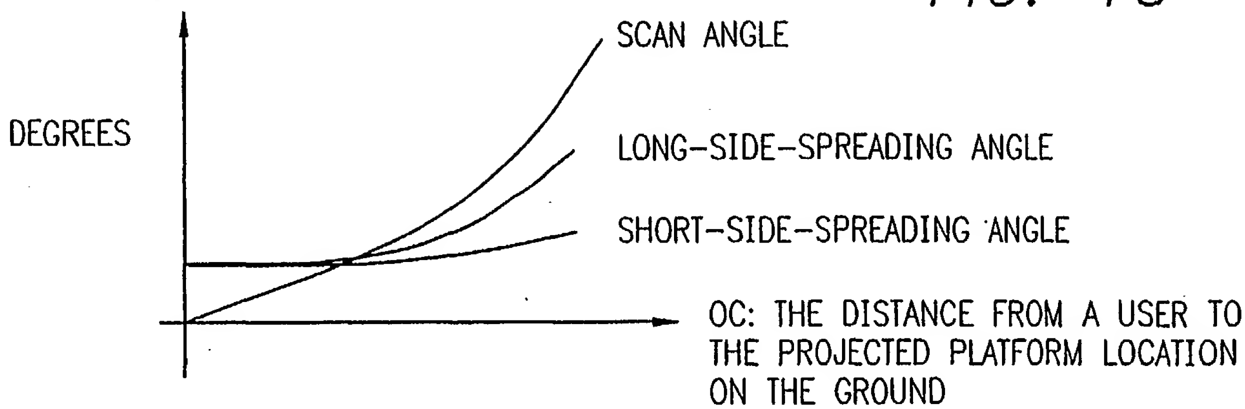
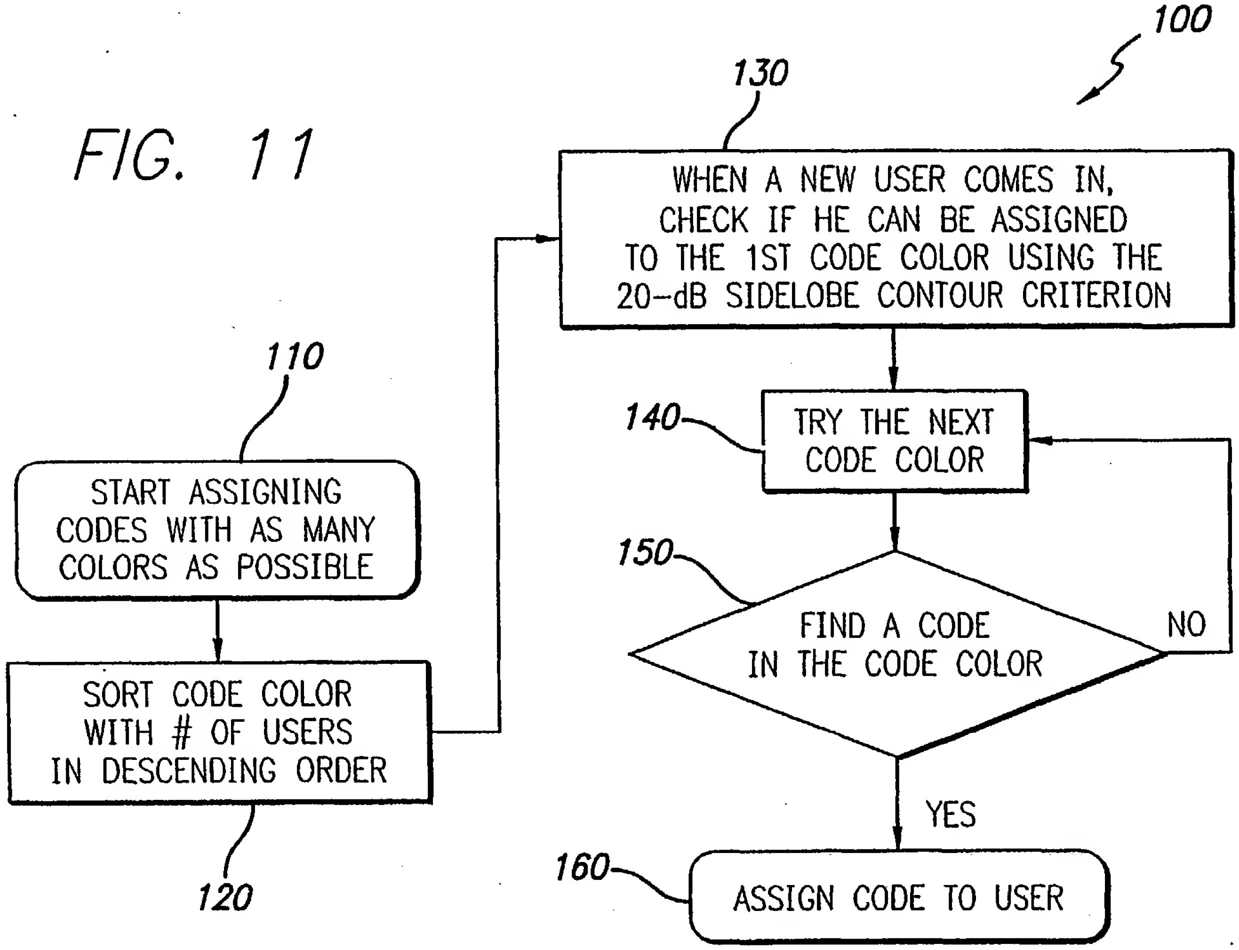



FIG. 11



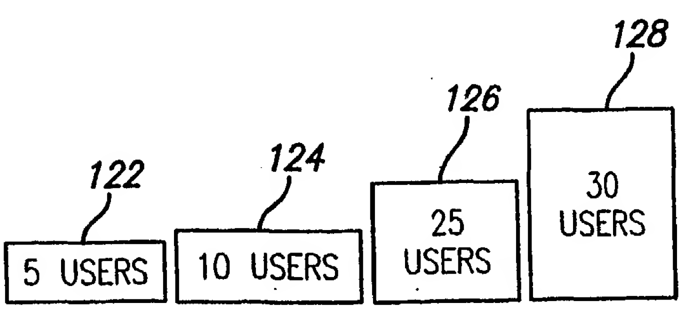




FIG. 12

FIG. 13

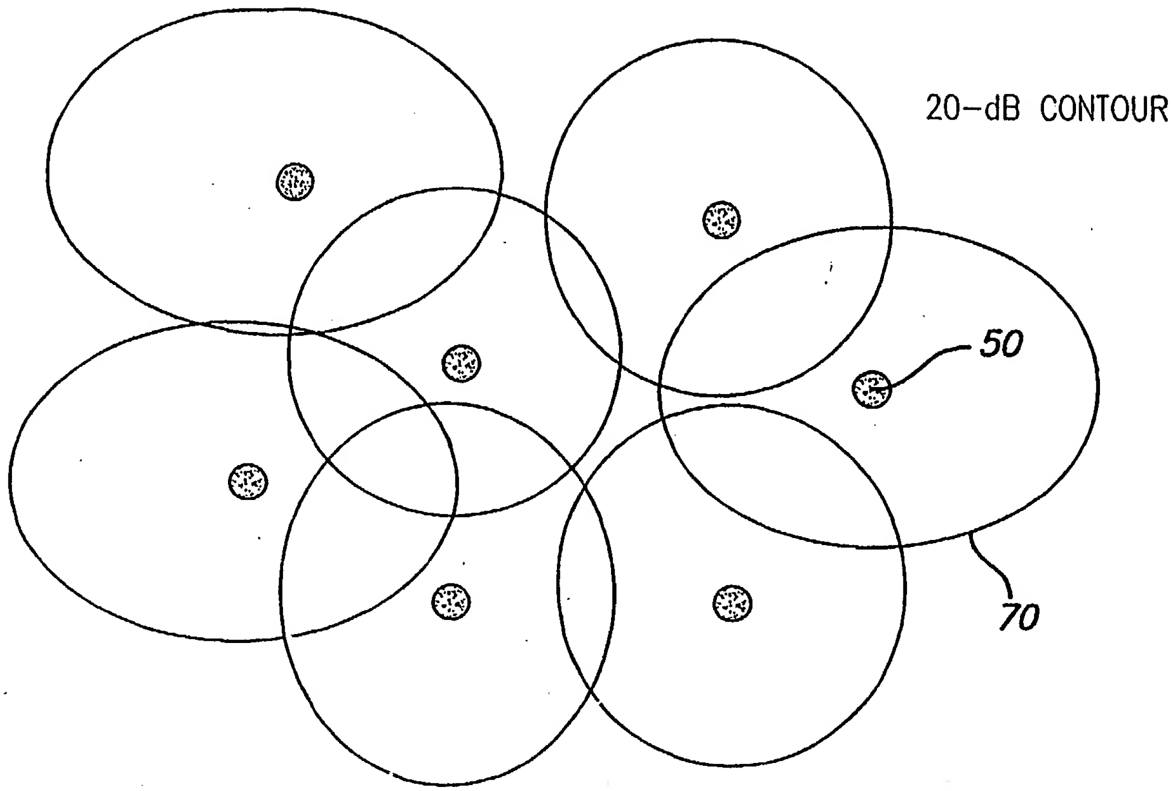



FIG. 14

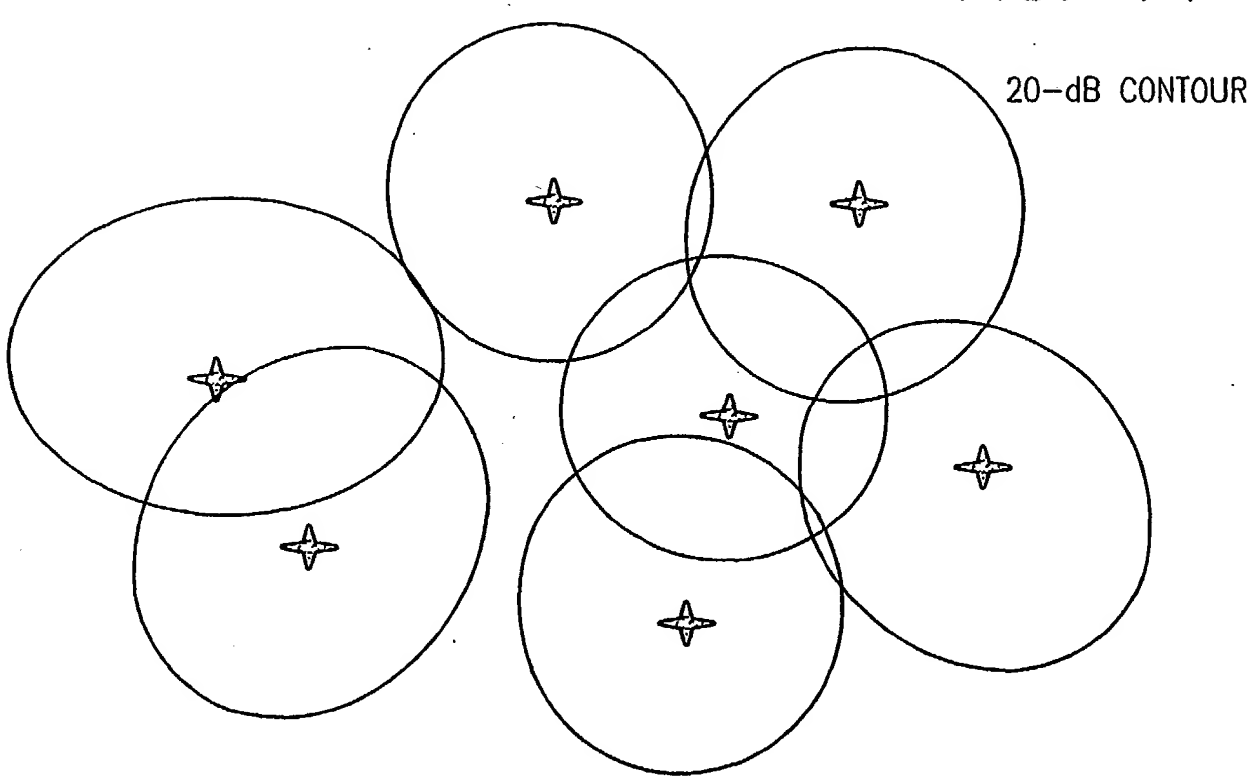


FIG. 15

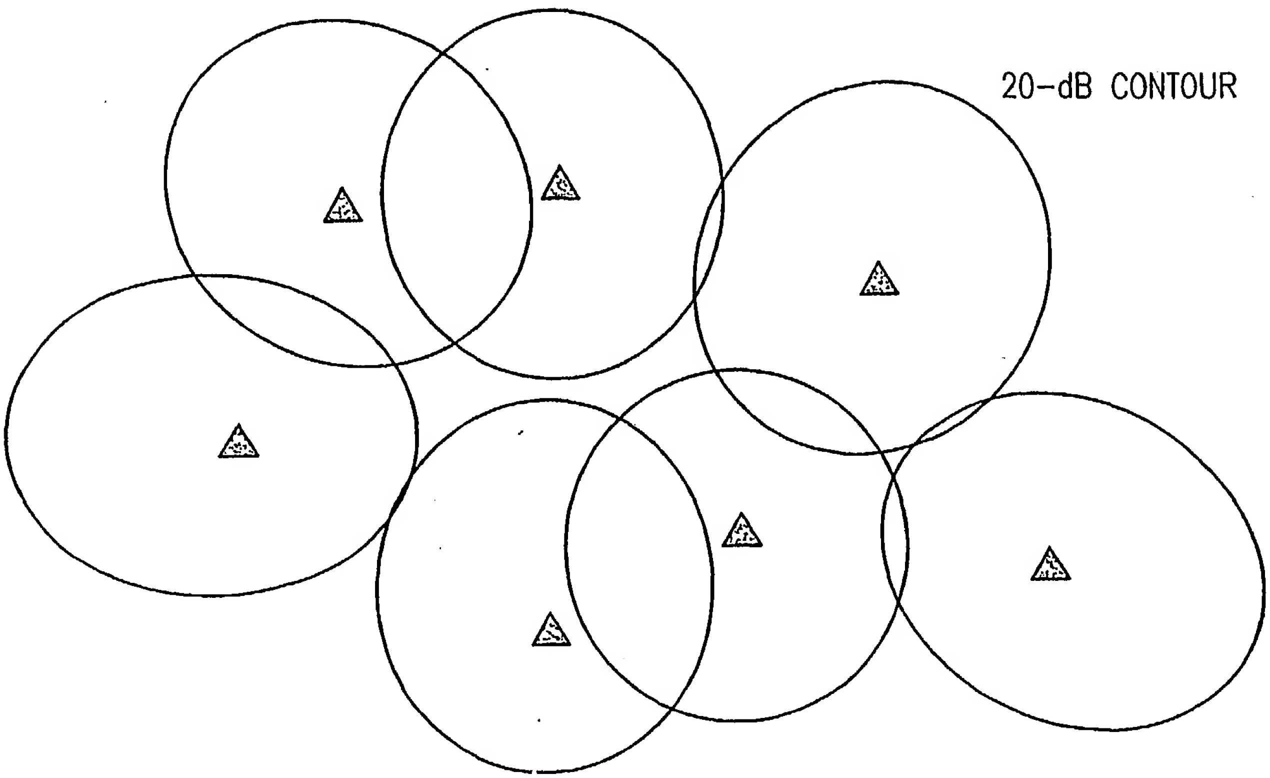



FIG. 16

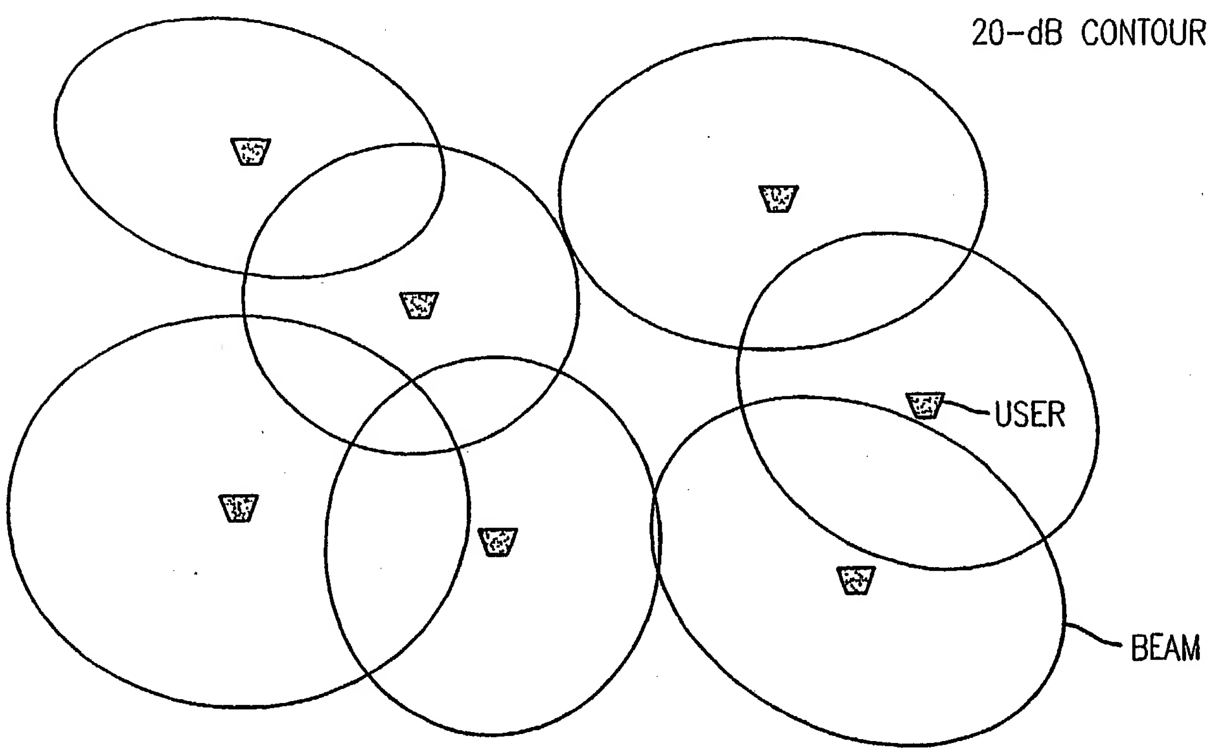


FIG. 17

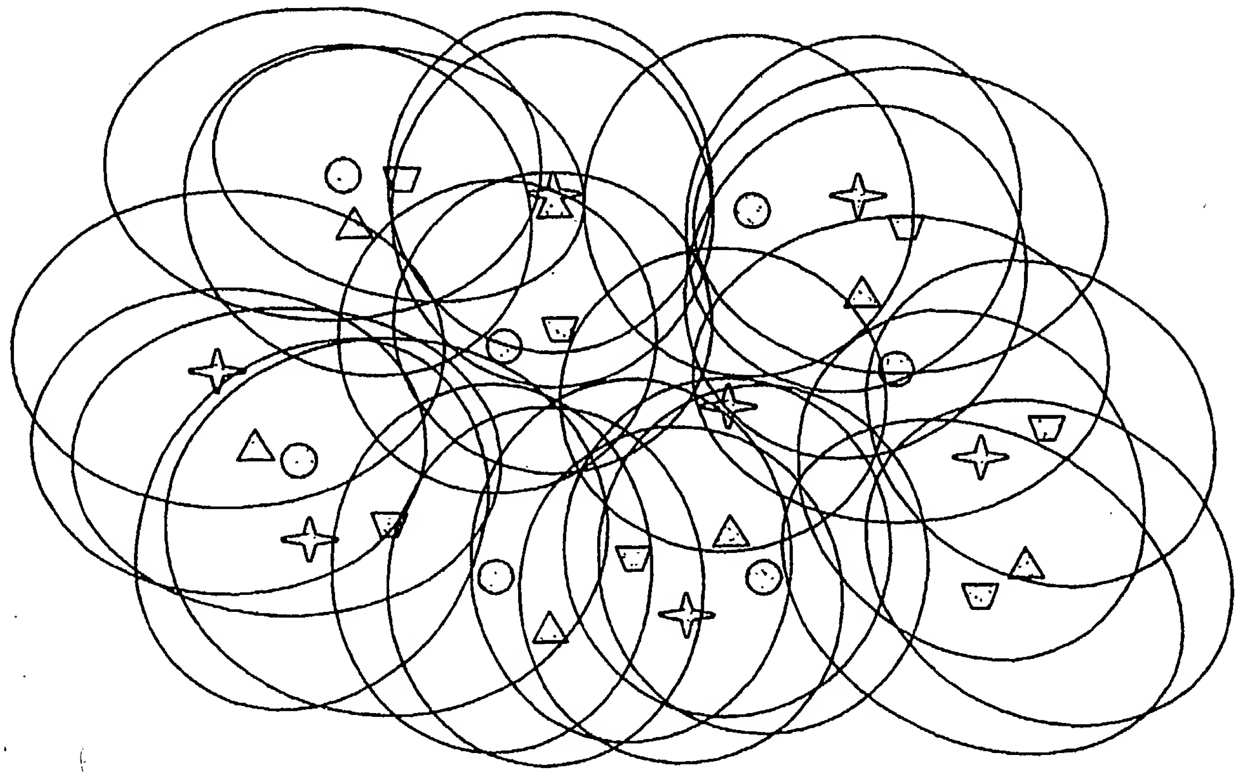


FIG. 18

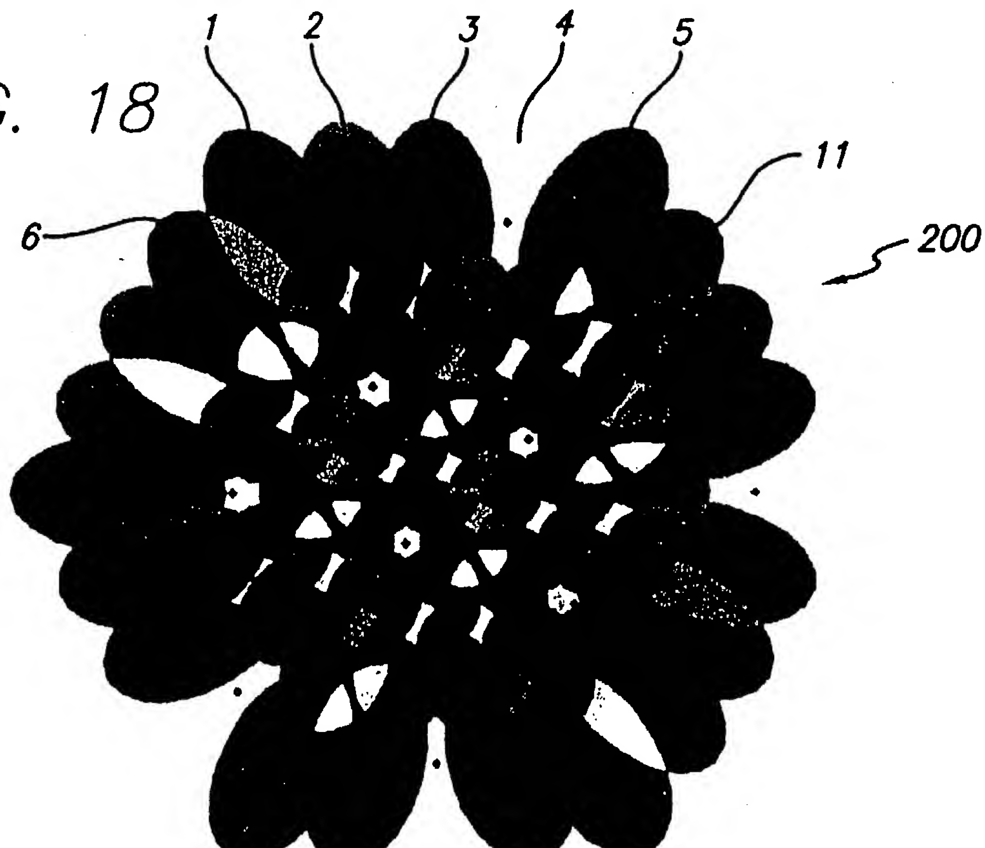


FIG. 19

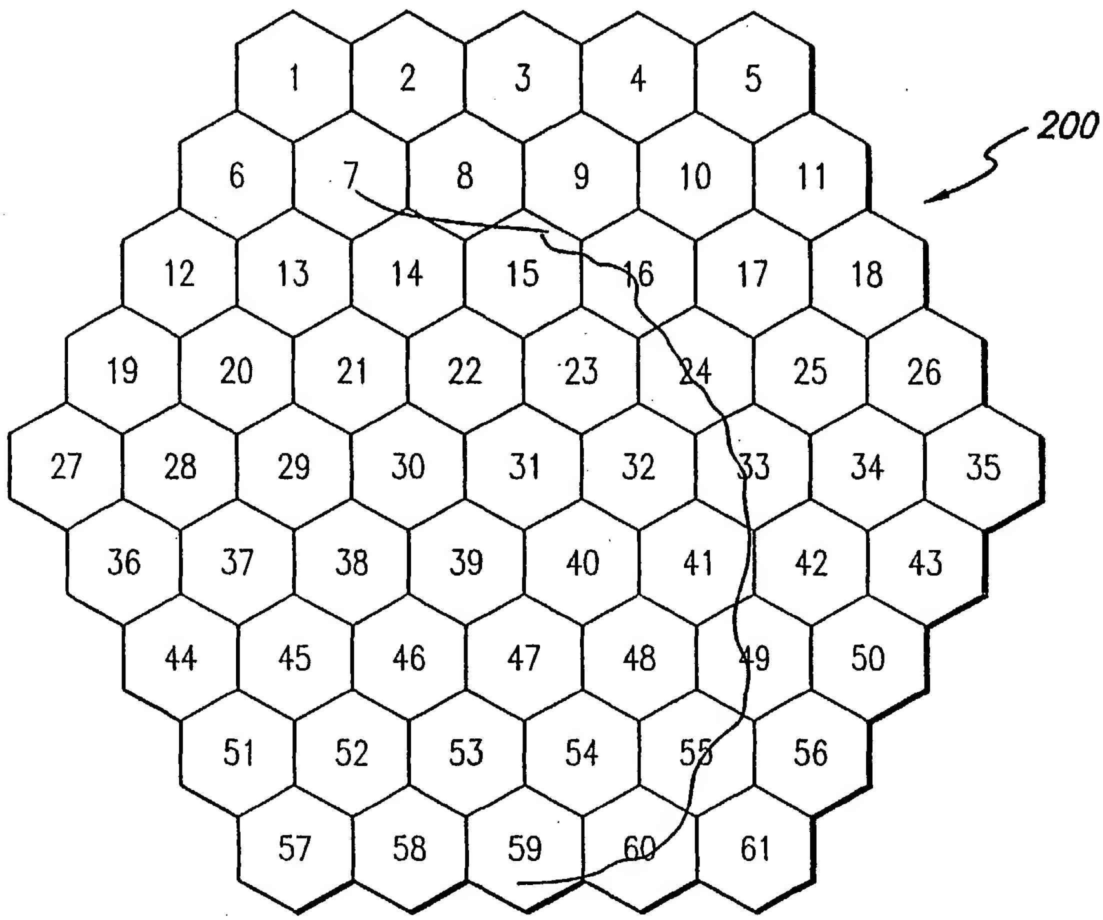

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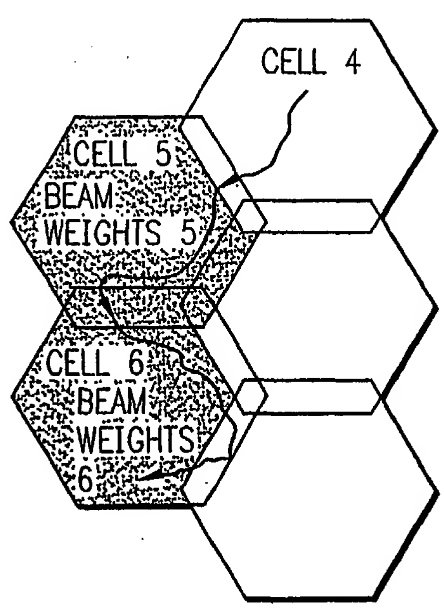
FIG. 20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CELL 5
BEAM
WEIGHTS 5
CELL 6
BEAM
WEIGHTS
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PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference | **FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. | |
|---|---|---|
| PD-200063P | | |
| International application No. | International filing date (*day/month/year*) | (Earliest) Priority Date (*day/month/year*) |
| PCT/US 01/17923 | 01/06/2001 | 06/06/2000 |
| Applicant | | |
| HUGHES ELECTRONICS CORPORATION | | |

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

[ ] the text is approved as submitted by the applicant.

[X] the text has been established by this Authority to read as follows:

MICRO CELL ACHITECTURE FOR MOBILE USER TRACKING IN A COMMUNICATION SYSTEM

5. With regard to the **abstract**,

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

[X] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[ ] None of the figures.

International Application No
PCT/US 01/17923

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 H04B7/185

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 6 020 845 A (WEINBERG AARON ET AL) 1 February 2000 (2000-02-01)<br>abstract<br>column 1, line 60 -column 2, line 19<br>column 2, line 47 -column 3, line 4<br>column 5, line 35-60<br>column 9, line 28-34<br>column 12, line 16-34<br>figures 1,2<br>claims<br>--- | 1-5,10, 11,13 |
| X | US 5 589 834 A (WEINBERG AARON) 31 December 1996 (1996-12-31)<br>the whole document<br>--- | 1-5,10, 11,13 |

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 March 2002 | 21/03/2002 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Dejonghe, O |

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication,where appropriate, of the relevant passages | Relevant to claim No. |
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| A | WO 97 07609 A (GOVER AVI ;KASTNER RAPHAEL (IL); UNIV RAMOT (IL))<br>27 February 1997 (1997-02-27)<br>abstract<br>page 4, line 27 -page 5, line 24<br>page 7, line 20 -page 8, line 10<br>figure 1<br>--- | 1-13 |
| A | US 5 612 701 A (DIEKELMAN DENNIS P)<br>18 March 1997 (1997-03-18)<br>the whole document<br>----- | 1-13 |

1

| Patent document cited in search report | | Publication date | Patent family member(s) | | Publication date |
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